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| **FERMILAB**<br>**TD/ SRF Development Department** | **ODH Analysis** | **Doc. No. TD-12-003**<br>**Rev. C**<br>**Date: 15 March 2012** |

# ODH (Oxygen Deficiency Hazard) Analysis for Engineering Lab – ICB

| Rev | Date | Description | Originated by | Approved by |
|---|---|---|---|---|
| C | 15 March 2012 | Amendment to existing analysis: new enclosure addition, new experiment specifications | N. Dhanaraj (X 2204) | T. Peterson (X 4458) |
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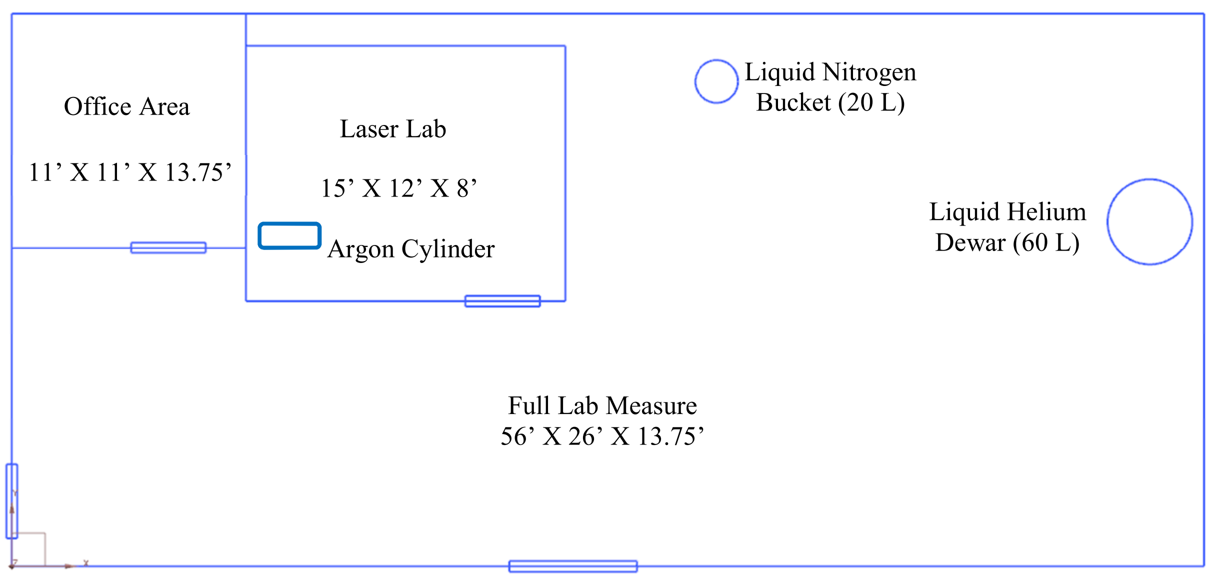
## Introduction:

The objective of this Technical Note is to present the details of an ODH (Oxygen Deficiency Hazard) analysis performed on the Engineering Lab located in the Industrial Center Building (ICB). The lab has been analyzed for ODH conditions previously in October 1991 by Tom Peterson and in January 2006 by Tom Nicol. The lab has been renovated since and furnished with an additional enclosure for Laser Re-melting experiments. The lab will also be conducting small sample thermal conductivity measurements. The oxygen depriving sources that have been specified are as follows:

- Up to 2 standard gas cylinders of argon used for purge gas for laser melting.
- One standard 160 L dewar of liquid nitrogen, although normal operations will use a 20 L nitrogen bucket filled from the dewars located outside ICB.
- One transport dewar containing 60 L of liquid helium, used for RRR tests.

The analyses follow the requirements and formulas provided in FESHM manual 5064.

## Floor Plan of Engineering Lab:




## Argon Gas Operations:

The lab procures argon as compressed gas available in 248 scf cylinders at 1500 psi for operations in the laser lab enclosure. For ODH calculations a worst case scenario is assumed which entails the full volume of 248 scf of argon gas lost at a rate of 150 scfh or 2.5 scfm. Comparing the scenario with the cases presented in FESHM 5064, case A has been chosen as the appropriate condition and the calculations are made based on the formulae available. The equation is given as below:

$$C(t) = \left(\frac{0.21}{Q+R}\right)\left[Q + Re^{-\left(\frac{Q+R}{V}\right)t}\right]$$

Where, C (t) = oxygen concentration at time t

Q = ventilation rate of fan in cfm

R = spill rate into confined volume in scfm

t = time, 0 at the beginning of release in minutes

V = confined volume, cubic feet (cf)

For the worst case scenario no ventilation is considered therefore, Q = 0. R, the spill rate is 2.5, V, the volume of the laser lab is 1440 cf and t, the time required for release of 248 scf at the maximum flow rate of 150 scfh is 99.2 minutes. The oxygen concentration C (t) calculated for 1 cylinder of argon gas leak using the above mentioned values is 17.6 % which is below the required safe limit of 18 %. Thus the leak from a 248 scf cylinder can result in an ODH scenario.

The above ODH problem can be mitigated by the use of a smaller volume argon gas cylinder. The calculations were repeated with a argon bottle of 150 scf capacity and the concentration of oxygen in this case was 18.9 % which is above the ODH required limit and in this case a leak scenario results in a classification of ODH 0 (zero).

***<u>Note:</u>***

Argon gas is heavier than air and tends to stratify from the floor level up. In the above case if 150 scf of argon were to leak into the laser lab it would rise up to a level of 0.83 feet off the floor.

***<u>Recommendation:</u>***

Restrict argon gas usage to 1 bottle at a time with a capacity of 150 scf at a maximum flow rate of 150 scfh to maintain ODH 0 conditions.

## Liquid Nitrogen Operations:

The liquid nitrogen usage in the lab is restricted to 20 L transport buckets from outside the building. Assuming a worst case scenario of the bucket toppling and all of the liquid nitrogen spilling on to the lab floor, an oxygen concentration is calculated. Nitrogen in the liquid form when exposed to atmospheric conditions can expand at a ratio of 1: 696. Thus a 20 L volume can turn into a 13920 L of gas or 492 cf of gas.

The oxygen concentration is calculated using the same equation as above. Q is assumed to be 0, R = 492 cfm, i.e. 492 cf of liquid nitrogen spills in 1 minute, V = 16916.25 cf, excluding the office area and laser lab. The oxygen concentration for the above parameters is 20.38 %

which is well above the safe limit and thus the liquid nitrogen operations do not cause an ODH scenario. The classification for these operations is ODH 0.

***Note:***

Since nitrogen gas/vapors is heavier than air it can also stratify and the spill of a 20 L bucket of liquid nitrogen can results in vapors up to 0.43' from the floor level.

## Liquid Helium Operations:

A liquid helium dewar of 60 L is used in the lab for small sample thermal conductivity studies. A failure event such as the loss of insulating vacuum can occur and helium could be released through the relief valves. As a worst case scenario and conservative approach, the loss of the full 60 L is assumed to occur in one minute. Liquid helium expands at a rate of 1: 757 and thus 60 L translates into 49205 L or 1738 cf of helium gas.

The oxygen concentration is calculated assuming Q=0, R=1738 cfm and V = 16916.25 cf and is found to be 18.9 %, which is above the safe upper limit required to classify the prevailing conditions as ODH 0.

***Note:***

Helium gas is lighter than air and tends to accumulate in the proximity of the ceiling. Assuming a stratified volume of helium gas in the event of a failure, the gas can be accumulated up to 1.5' from the ceiling down.

## Conclusions and Recommendations:

The Engineering Lab has been reviewed for any prevailing ODH conditions as per the operation specifications described. The results of the analysis have been presented in this note. In the case of argon gas operations an ODH 0 classification requires the use of 1 bottle of argon gas of capacity 150 scf at a maximum flow rate of 150 scfh. As for the liquid nitrogen operations the spill of a 20 L bucket in 1 minute falls under category ODH 0. In the event of a leak from the liquid helium dewar and the full volume of 60 L leaking in 1 minute the ODH classification is again zero. Any modifications to the above mentioned parameters or modes of failures will have to be reviewed for ODH safety.

## Appendix:

***Abbreviations:***

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| L- liters |
| scf – standard cubic feet |

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| scfh – standard cubic feet per hour |
| scfm – standard cubic feet per minute |
| cf – cubic feet |
| cfm – cubic feet per minute |